**Unit 5, Part 3 (Cell Structure and Transport): Water Potential Calculations Tutorial**

Ms. Ottolini, AP Biology

1. **What is water potential?**

* Water potential is the force responsible for the movement of water in a system.
* It is a measure of the free energy of water, which is lower when it has to surround solutes
* Pure water (no solutes) has a water potential of zero. As more and more solutes are added, water potential becomes more negative.
* Water potential is given the symbol psi (Ψ) and is measured in bars or megapascals

1. **What are the factors that affect water potential?**

* Solute potential (also called osmotic potential) has the symbol (Ψs) and is determined by solute concentration. In pure water, the solute potential is zero. As more and more solutes are added, solute potential becomes more negative.
* Pressure potential has the symbol (Ψp) and results from exertion of pressure on cell membranes/walls as water moves into the cell. It is typically a positive value.
* The equation that describes the effects of solute potential and pressure potential on water potential is given below.

**Calculation #1: Ψ = Ψs + Ψp**

1. **So how does the movement of water relate to water potential?**

* Water moves from areas of higher water potential (i.e. high water concentration, low solute concentration) to areas of lower water potential (i.e. low water concentration, high solute concentration)

1. **If you know the molarity (concentration) of solute in a solution, how do you find the solute potential?**

* You use the calculation given below:

**Calculation #2: Ψs = -iCRT**

* The variables for this equation are defined as follows:

i = ionization constant (1 for a solute that does not dissolve / break apart in water, 2 for a solute like NaCl that breaks apart into two ions – Na+ and Cl-)

C = molar concentration of the solute

R = pressure constant (0.0831 liter/bars/mole K for sucrose)

T = temperature in Kelvin (degrees Celsius + 273)

1. **Practice Problems**

**Problem #1:** The initial molar concentration of the cytoplasm inside a cell is 2M and the cell is placed in a solution with a concentration of 2.5M. For each statement below, write A if the statement is true and B if the statement is false. If the statement is false, please correct it.

1. Initially, free energy is greater inside the cell than outside

**A**

1. It is possible that this cell is already in equilibrium with its surroundings.

**B (The cell must lose water to reach equilibrium)**

1. Initially, solute concentration is greater outside the cell than inside.

**A**

1. Water will enter the cell because solute potential is lower inside the cell than outside.

**B (Water will leave the cell because solute potential and water potential are higher / less negative inside the cell than outside the cell).**

1. Initially, the cytoplasm is hypertonic to the surrounding solution.

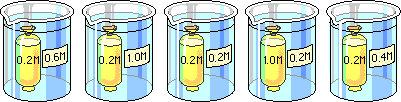
**B (Initially, the cytoplasm is hypotonic to the surrounding solution)**

1. At equilibrium, the pressure potential inside the cell will have increased

**B (At equilibrium, the pressure potential inside the cell remains zero. There is only pressure potential when water enters the cell and pushes against the cell wall / cell membrane to create pressure)**

**Problem #2:** A student conducted an experiment to track the movement of water across a selectively permeable membrane (dialysis tubing). He filled bags of dialysis tubing with solution of varying sucrose (sugar) concentrations and recorded an initial mass for each bag. He then placed these bags in beakers containing solutions of varying sucrose concentrations. He let the beakers sit for 30 minutes, removed the bags, and recorded the final mass of each bag. Images of the bags and beakers used (with sucrose molarities given) are shown below.

**1 2 3 4 5**



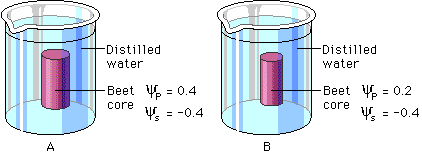
1. Which beaker(s) contain a solution with a higher (less negative) water potential and solute potential than the solution inside the dialysis bag?

**Beaker #4**

1. Which bag would you predict to show the largest decrease in mass at the end of the experiment? Explain your answer in terms of water potential.

**Bag #2 will show the largest decrease in mass because it has a much higher water potential than the surrounding solution and water will move out of the bag towards an area of lower water potential.**

**Practice Problem #3:** A student placed two beet cores in beakers containing distilled water (0% solute) at different times. The beakers are shown below, and the solute potential and pressure potential of the beet cores are given.



1. Which beet core has been in the distilled water the longest? How do you know?

**Beet Core A. Its pressure potential has gotten higher and higher as water has entered the core and exerted pressure on the cell walls of the beet cells. At this point, the water potential of the beet core is zero due to the opposing effects of solute potential and pressure potential. The beet core is now equilibrium with the surrounding solution. Water will not continue to move into the beet core.**

**Ψs + Ψp = Ψ 🡪 (-0.4) + (0.4) = 0**

1. What is the water potential of the distilled water in Beaker B?

**The water potential of distilled (pure) water is always zero.**

1. What is the water potential of the beet core in Beaker B?

**The water potential of the beet core in Beaker B is -0.2 bars.**

**Ψs + Ψp = Ψ 🡪 (-0.4) + (0.2) = -0.2**

1. Predict the movement of water either into or out of the beet core in Beaker B. You must refer to the water potential of the distilled water and the water potential of the beet core in your response

**Water will move into the beet core in Beaker B from a higher water potential (distilled water) to a lower water potential (beet core). This will occur until the pressure potential of the beet core is -0.4 and equilibrium is reached.**

**Practice Problem #4:** What is the solute potential of a 0.1 M solution of sucrose at 22 C? *(Note: Sucrose does not break apart in water!)*

**-iCRT = Ψs 🡪 - (1) (0.1) (0.0831) (22+273) = -2.45**